Electronic States of Nano-Graphite Möbius Ribbon in a Magnetic Field

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Carbon based nano-scale materials such as fullerenes and carbon nanotubes are attracting much attention due to their novel electronic properties. In these systems, the geometry of sp^2 carbon networks crucially affects the electronic states near the Fermi level. The electronic states of carbon nanotubes are classified by the chiral vector which assigns the diameter and chirality of the nanotubes. Besides the closed carbon molecules, systems with open boundaries also display unusual features connected with their shape.[1] Nanographite ribbons, one-dimensional graphite lattices with a finite width, have shown that ribbons with zigzag edges (zigzag ribbon) possess localized edge states near the Fermi level. These edge states correspond to non-bonding molecular orbitals. Such states are completely absent for ribbons with armchair edges. Thus the topology of the sp^2 carbon networks is decisive to the electronic properties of the nanographite system.

Recently, a $NbSe_3$ Möbius strip has been fabricated.[2] The Möbius strip is a twisted loop which has one-sided surface. It is quite intriguing that a crystalline ribbon forms this exotic topology. Such the novel experimental finding motivated us to study the electronic properties of nanographite ribbons with the Möbius boundary condition.[3] The main purpose of this paper is to clarify the electronic states of the nanographite Möbius ribbon, on the basis of the nearest-neighbor tight-binding model. It is found that the electronic levels of the zigzag ribbon with Möbius boundary condition can be derived from the same way to derive the electronic levels of Möbius strip with a free electron system or square lattice system. However, the armchair ribbon with Möbius boundary condition does not follow the same rule. We will present the origin of this difference occurred in the derivation of the electronic levels in the connection with the topological nature of Möbius strip. Furthermore, we study the effect of the magnetic field threading the nanographite Möbius ring. The magnetic field drives the persistent current along the ring. In the cylindrical (Möbius) geometry, an electron moving the longitudinal direction along the ring encircles the system once (twice) before returning to the initial position. Thus the different flux periodicities of the persistent current are expected between two cases. We also compare the behavior of persistent current between two different edge structures. The disorder effects on the persistent current are also discussed in the conference.

References

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